PERFORMANCE OF PLASTIC WASTE IN ASPHALT MIXTURE THROUGH DRY PROCESS

SAIFUL AMRI BIN MUHAMMAD GHAFI

B. ENG(HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

_____

(Student's Signature)

Full Name : SAIFUL AMRI BIN MUHAMMAD GHAFI

ID Number : AA15202

Date : 31 MAY 2019

PERFORMANCE OF PLASTIC WASTE IN ASPHALT MIXTURE THROUGH DRY PROCESS

SAIFUL AMRI BIN MUHAMMAD GHAFI

Thesis submitted in partial fulfillment of the requirements for the award of the
B. Eng (Hons.) Civil Engineering

Faculty of Civil Engineering & Earth Resources

UNIVERSITI MALAYSIA PAHANG

MAY 2019

ACKNOWLEDGEMENTS

First and foremost, I would like to thank my research supervisors, Associate Professor Dr. Ramadhansyah Putra Jaya. Without his assistance and dedicated involvement in every step throughout the process, this paper would have never been accomplished. I would like to thank you very much for your support and understanding over these past years. I would like to express my gratitude to my parents and family because gave me a consistent love and supported during my study. They give me strength and spirit so that I can able to finish my research work.

Besides, I am very thankful to all the staffs in Highway and Traffic Laboratory especially to Madam Sarah, Sir Sani and Sir Amir where they were assisted me started from the beginning until the end of the project. The commitment shown by them are very encouraging which they always kept an eye every time I am doing my research study. Their assistance and helpfulness are appreciated.

Apart from that, I also give a very high appreciation to my UMP's friends which they taught me a lot to perform every test conducted. They give me a fully supported during the project work. They give a great cooperation in making the schedule for the laboratory work and yet will make everyone in the field done their part successfully.

ABSTRAK

Plastik telah menjadi sebahagian daripada gaya hidup kita hari ini. Ia digunakan untuk apa-apa keperluan kehidupan seharian kita seperti pembungkusan, untuk melindungi tujuan, dan maksud perkhidmatan. Pengeluaran besar-besaran plastik akan menjadi baik kerana dapat menghasilkan pendapatan yang tinggi untuk industri. Terdapat beberapa percanggahan dalam industri plastik yang boleh menjadi bahan buangan dan memberi kesan buruk terhadap alam sekitar. Pelupusan plastik sisa nampaknya menjadi masalah utama di seluruh dunia sejak pengeluarannya mungkin tinggi disebabkan oleh permintaan yang tinggi. Secara logiknya plastic dicampur ke dalam campuran bitumin untuk pembinaan jalan berbanding membakar plastik buangan yang boleh menyebabkan pencemaran alam sekitar yang buruk. Hasil kajian terhadap plastik buangan yang dimasukkan ke dalam campuran asfalt telah dijalankan untuk menyiasat prestasi plastik sisa antara campuran asfalt yang diubahsuai dan campuran asfalt konvensional dan untuk mengkaji peratusan optimum bahan buangan plastik yang ditambah dalam campuran asfalt. Kajian ini menggunakan beberapa ujian untuk mengenal pasti prestasi plastik buangan dalam campuran asfalt. Ujian Marshall, ujian modulus yang berdaya tahan dan ujian rayapan dinamik telah dilakukan dengan mengambil tiga sampel setiap peratus plastik iaitu 0%, 5%, 7% dan 9%. Untuk ujian modulus berdaya tahan, pada 25 ° C campuran asfalt konvensional menunjukkan hasil terbaik dibandingkan dengan campuran asfalt yang diubahsuai di mana-mana peratusan plastik buangan ditambah. 7% daripada plastik ditambah adalah hasil tertinggi sebelum ia menurun apabila 9% plastik sisa ditambah. Pada 40 ° C hasilnya agak tidak konstan yang mana ia meningkat dan menurun pada setiap peringkat peratusan. Untuk ujian rayapan dinamik, campuran asfalt optimum adalah 9% di mana ia menunjukkan hasil yang lebih besar berbanding dengan peratusan lain yang terdapat dalam plastik buangan. Ini menunjukkan bahawa prestasi plastik buangan dalam campuran asfalt diubahsuai mempengaruhi keputusan setiap ujian yang telah dilakukan. Campuran asfalt yang optimum adalah berbeza pada setiap ujian yang dijalankan. Dapat disimpulkan bahawa peratusan tambahan plastik boleh memberi hasil yang lebih besar berbanding campuran asfalt konvensional.

Kata kunci: plastik sisa, peratusan optimum, modulus berdaya tahan, modulus creep

ABSTRACT

Plastic have become part of our today's lifestyle. It is used for any needs of our daily life such as packaging, for protecting purpose, and serving purpose. The mass production of plastic would be good as its can produce a high incomes for the industries. There are some contradict in plastic industries which it can be a waste material and give the bad effect in environment. The disposal of waste plastic seems to be a major problem worldwide since the production of it may be high due to the high demand. Plastic is a non-biodegradable and it mainly consists of low-density polytethylene. Furthermore, it is logically to be mixed into the bituminous mixes for road construction rather than burning the waste plastic that can lead to the bad environmental pollution. The researched of the waste plastic added into the asphalt mixture had been carried on to to investigate the performance of waste plastic between modified asphalt mixture and conventional asphalt mixture and to study the optimum percentage of plastic waste added in asphalt mixture. This study used several test to identify the performance of the waste plastic in the asphalt mixture. Marshall test, resilient modulus test and dynamic creep test had been done by taking three samples of each percentage of plastic which is 0%, 5%, 7% and 9%. For the Resilient Modulus test, at 25°C the conventional asphalt mixture show the best result compared to the modified asphalt mixture at any percentage of waste plastic added. 7% of plastic added is the highest result before it decreased when 9% of waste plastic is added. At 40°C the result quite not constant which it increased and decreasing at every stage of percentages. For the dynamic creep test, the optimum asphalt mixture is at 9% where it shows greater result compare to the other percentage of the waste plastic added. This shows that the performance of the waste plastic in modified asphalt mixture influence the result of every test that had been done. The optimum modified asphalt mixture is different at every test conducted. It can be concluded that the percentage of plastic added may give the greater result compare to the conventional asphalt mixture.

Keywords: *waste plastic, optimum percentage, resilient modulus, creep modulus*

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Material
BS EN	British Standard
CO	Carbonyl Index
HMA	Hot Mix Asphalt
JKR	Jabatan Kerja Raya
PMB	Polymer Modified Bitumen
PEM	Porous European Mix
UTM	Universal Testing Machine
VFA	Void in Filled Asphalt
VMA	Void in Mineral Aggregate
VTM	Void in Total Mix

CHAPTER 1

INTRODUCTION

1.1 Research Background

Plastic have become part of our today's lifestyle. It is used for any needs of our daily life such as packaging, for protecting purpose, and serving purpose. The mass production of plastic would be good as its can produce a high incomes for the industries. There are some contradict in plastic industries which it can be a waste material and give the bad effect in environment. Plastic non-biodegradable so that it is not eco-friendly but it still user friendly. Today, there are a billion tonnes of plastic are being used and it seems to be increase day by day even though there are a lot of country which are banning the use of plastic waste due to the environment friendly policies. They also have a very long lifetime and burning of plastics waste under uncontrolled conditions and it also lead to generation of hazardous air pollutant depending upon the type of polymers and additives used. But instead of looking at the bad side of the waste plastic, it is actually can be very useful in other development such as road construction. The presence of waste plastic seems to lead to an environmental pollution, but with the previous and further studies, it can be the additive for the bitumen for the road construction. Many of the countries are looking forward in order to enhance and improve their properties of road pavement and construction and in term of cost saving, waste plastic seems to be the right choice to be implement into the road construction experiment.

Over the past two decades, traffic volumes have increased rapidly and the demanding from pavement engineers, stronger and long lasting pavements have also increase. New methods of pavement design are being developed and experimentally conducted to improve the performance of roads. New materials, one after another, are

being used to replace the old ones to improve the strength, economy, aesthetics and durability. One of the productive ways is to use the waste plastics in bituminous road construction industries. Today, the waste plastics is enormous available, as the plastic materials have become very useful part of the daily life. If not recycled, their present disposal is either by land filling or by incineration. Both these processes either land filling or by incineration have certain impact on the environment in term of pollution. Under this circumstance, an alternate use for the waste plastics is the need of the time.

Plastic bag is non-biodegradable but most of it is recyclable. The recycled products are more environmentally harmful than the first manufactured ones because every time plastic is recycled it is subject to high intensity heat. This can make it to deteriorate and lead to effect the environment. That is why it is a must to determine the effective way to deal with this non-biodegradable waste in order to ensure the environment in always in 'go-green' mode. The experimentation at some places indicated that the waste plastic, when added to hot aggregate will form a fine coat of plastic over the aggregate and such aggregate, when mixed with the binder is found to give greater strength, higher resistance to water and better overall performance vary with the period of time. Use of higher percentage of plastic waste reduces the need of bitumen by 10% and it leads to the saving of cost. It also increases the strength and performance of the road as a lot of previous studies have been conducted and proven

1.2 Problem Statement

The disposal of waste plastic seems to be a major problem worldwide since the production of it may be high due to the high demand. Plastic is a non-biodegradable and it mainly consists of low-density polytethylene. Furthermore, it was logically to be mixed into the bituminous mixes for road construction rather than burning the waste plastic that can lead to the bad environmental pollution. The laboratory test had been performed in order to conduct on these bituminous mixture. From the previous studies, it was shows that plastic waste improves the performance of bitumen when it was added into bitumen. The usage helps to improve the performance of the road pavement which also reduces the rutting effect.

1.3 Objective

The objective of this study are:

I. To investigate the performance of waste plastic between modified asphalt mixture and conventional asphalt mixture.

II. To study the optimum percentage of plastic waste added in asphalt mixture.

1.4 Scope of Research

This research was to analyze the properties of waste plastic bags used in order to get the optimum bitumen content for every waste plastic added in an asphalt mixture and to investigate the performance between the modified asphalt mixture and conventional asphalt mixture. The waste plastic was collected from the area around university campus and being shred afterwards. The aggregate used AC14 and the grade of bitumen used was 60/70. There are several Standards that have been used for this research which it complies with JKR, ASTM, and BS EN. This research had been conducted with several experiment which are Marshall Mix Design, Dynamic Creep Test, Resilient Modulus Test and Marshal test. All test will come out with 3 samples each which are samples containing 0%, 5%,7% and 9% addition of waste plastic.

1.5 Significance of Research

This research can solve the problem of abundance of waste plastic that lead to environment pollution by mixing it into the bitumen for the road construction. Waste plastic can increase the performance of the bitumen yet improved the quality of the road construction. The production of this asphalt mixture gave the advantages for the industry in term of cost as the waste plastic can be getting in lower price. The rapidly growth of the plastic industry yet became a serious problem when there was no experimental conduct of it on how to make it more useful even after being used.

REFERENCES

Associates, C. (1988). *DEVELOPMENT OF IMPROVED MIX AND CONSTRUCTION*.

Baghaee Moghaddam, T., Soltani, M., & Karim, M. R. (2014). Evaluation of permanent deformation characteristics of unmodified and Polyethylene Terephthalate modified asphalt mixtures using dynamic creep test. *Materials and Design*, *53*, 317–324. https://doi.org/10.1016/j.matdes.2013.07.015

Brown, S. F. (1997). Achievements and Challenges in Asphalt Pavement Engineering. *Proceedings of the 8th International Conference on Asphalt Pavements*, 1–21. Retrieved from http://asphalt.org/downloads/Browns_lecture.pdf

Buncher, M., & Anderson, M. (2014). *MS-2 7 th Edition Asphalt Mix Design Methods*.

Free, F., Buchanan, S., Cooper III, S., Mohammad, L., Ozer, H., Al-Qadi, I., … Aschenbrener, T. (2018). Innovations in Asphalt Mixture Design Procedures. *Innnovatios in Asphalt Mixture Design Procedures*, (October), 77.

Gawande, A., Zamare, G., Renge, V. C., Tayde, S., & Bharsakale, G. (2012). An Overview on Waste Plastic Utilization In Asphalting of Roads. *Journal of Engineering Research and Studies*, *3*(2), 1–5. https://doi.org/10.1016/j.steroids.2009.10.005

Kalantar, Z. N., Karim, M. R., & Mahrez, A. (2012). A review of using waste and virgin polymer in pavement. *Construction and Building Materials*, *33*, 55–62. https://doi.org/10.1016/j.conbuildmat.2012.01.009

Kandhal, P. S. (1992). *MOISTURE SUSCEPTIBILITY OF HMA MIXES : IDENTIFICATION OF PROBLEM AND RECOMMENDED*. (May).

Khodary, F. (2019). Experimental Study of using Waste Glass as additives in Asphalt Concrete Mixtures. *International Journal of Advances in Scientific Research and Engineering*, *4*(12), 210–214. https://doi.org/10.31695/ijasre.2018.33030

Njeru, J. (2006). The urban political ecology of plastic bag waste problem in Nairobi, Kenya. *Geoforum*, *37*(6), 1046–1058. https://doi.org/10.1016/j.geoforum.2006.03.003

SultanaSK, A. (2012). Utilization of Waste Plastic as a Strength Modifier in Surface Course of Flexible and Rigid Pavements. *International Journal of Engineering Research and Applications (IJERA)*, *2*(4), 1185–1191. Retrieved from www.ijera.com

Testing, A. (2011). *Chapter 7 Testing of Asphalt Concrete Mixtures*. 1–36. Retrieved from http://www.virginiadot.org/business/resources/Materials/MCS_Study_Guides/bu-mat-Chapt7AP.pdf

Thompson, R. C., Moore, C. J., Saal, F. S. V., & Swan, S. H. (2009). Plastics, the environment and human health: Current consensus and future trends. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*(1526), 2153–2166. https://doi.org/10.1098/rstb.2009.0053

Turnbull, W J, "Appraisal of the CBR method",Development of CBR flexible pavement designmethod for airfields - a symposium, *Trans. ASCE*, 547-554, 2016.

Viggiani, G and Atkinson, J H, "Stiffness of fine-grainedsoil at very small strains", *Géotechnique*, 45, No. 2,249-265, 2010.

Vucetic, M and Dobry, R . "Effect of Soil Plasticity onCyclic Response", *J. Geotech. Engrg, ASCE*, 117, No.1, 89-107, 2011.

Wheeler, S J and Karube, D, "State of the art report -constitutive modelling", *Proc. 1st Int. Conf. onUnsaturated Soils*, Paris, 2015.

Witczak, M W and Shook, J F, "The Arm ArborConference: Thirty years' contribution to asphalttechnology", *Proc. 7th Int. Conf. on Asphalt Pavements*,Vol. 5, Nottingham, pp 7-67.

W.R. Lovering and H.R. Cedergren. Structural Section Drainage. Proc. InternationalConference on the Structural Design of Asphalt Pavements, Ann Arbor, Michigan, 2012.